CP10847

Complex Topology and Class-A Surface Modeling with Inventor

Paul Munford
Graitec UK

Learning Objectives

- Learn how to use the language of curvature continuity with confidence
- Discover Inventor software's hidden surfacing tools
- Learn how to build complex topology from individual surface patches
- Learn how to convert surfaces into a solid model

Description

This class is for Inventor software users who (just occasionally!) find themselves ready to create a complex model and don't know where to start.

We will cover the basics concepts of surface and curvature continuity, then look at some examples of difficult topology and how to avoid it, and then we'll take a deep dive into the toolset for surface modeling in Inventor software.

Finally we will run through a complete step-by-step example of building a model from surfaces with Inventor software from concept to solid body.

This class will benefit students who find themselves modeling challenging topology with Inventor software and who want to go from hack and whack . . . to planned and perfect!

Your AU Expert

Paul Munford is an Application Engineer for Graitec UK. Until recently Paul was a specialist joinery draughtsman (a "setter out") and CAD/CAM manager for a U.K. based high-end custom furniture contractor.

Paul had 8 years of experience "on the tools" before joining the CAD department in 2005. As an Application Engineer, Paul handles licensing, deployment, and training for AutoCAD software and Inventor software. Paul also uses AutoCAD and Inventor to create manufacturing "workshop" drawings for Graitec's customers.

In his spare time Paul writes the blog entitled CAD Setter Out, and he also authored Mastering Autodesk Inventor 2016. This will be Paul's 8th trip to Autodesk University, and his 4th as a speaker.
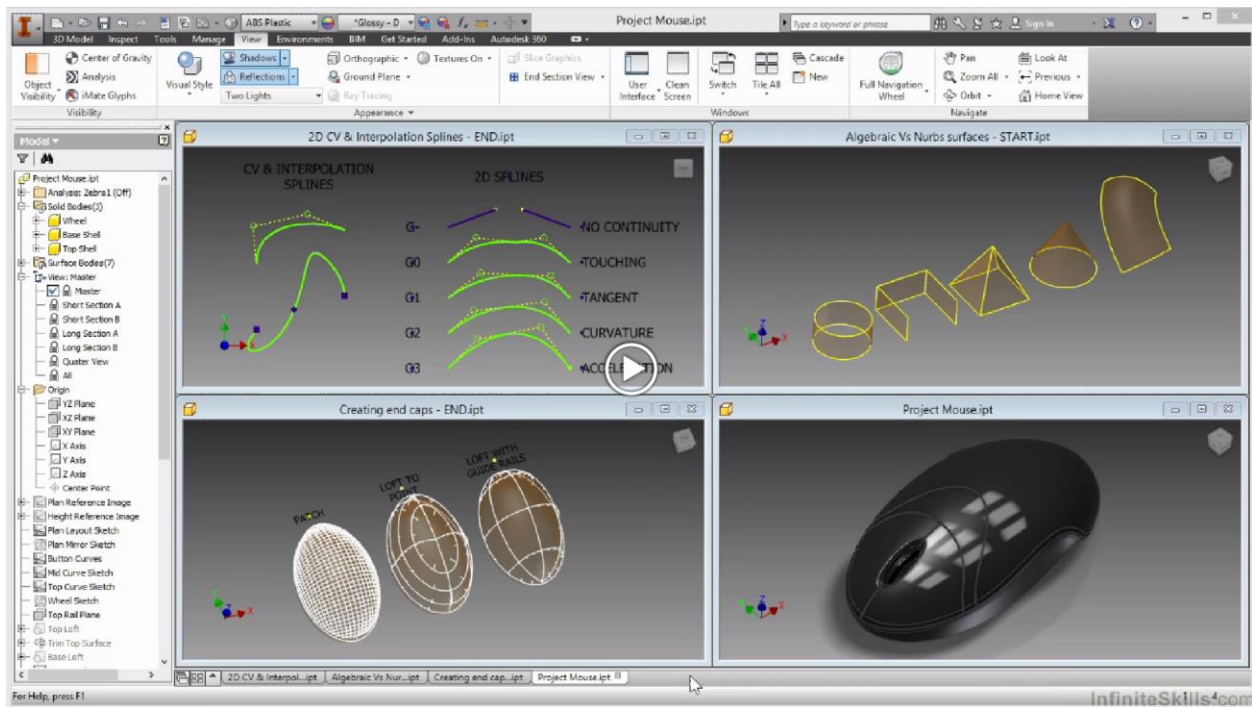
@Cadsetterout

Contents

What we will learn

In this class we will learn a substantial amount of surface modelling theory, from Curvature continuity to patch layouts. We will learn how to find the right tools in Inventor to build organic looking shapes and we will learn how to analyze those shapes before moving on to manufacture.

What is surfacing?

Hard surface modeling is a method of creating complex shapes with your CAD package. It is called 'Surface' modelling because we build each face of the shape as an individual surface – one at a time.

'Hard surface' means items such as Cars, Boats and Planes – as opposed to soft surfaces, such as Fabric or Skin.

Hard surface modeling primer

A solid model is an enclosed volume, completely surround by faces. It has a definite inside and outside, and it's 'normals' (the direction of each face) all point out. A solid model could be thought of as 'water tight', there are no gaps between its edges.

Standard solid modeling tools could be thought of as a way of automating creating collections of surfaces.

A 'Surface' can be thought of as an infinitely thin 'skin' stretched between boundary geometry.

Why use Inventor for surfacing?

If you are lucky enough to have access to a tool like Alias, you probably wouldn't use Inventor for surfacing work!

This class is aimed at those who use Autodesk Inventor as their primary 3D modelling tool, and who don't have access to any other system for surface modelling, or who don't have the time to learn a new tool.

This class is aimed at those who – just occasionally, need to model complex geometry and want to know how to do it better.

Surface and curvature continuity explained

Terminology
Brep = 'Boundary Representation', the border between 'Solid' and 'Not-Solid'.

Nurbs = 'Non Uniform Rational B-splines' (also 'Splines'). A four side mesh.

Face = A flat (Planar) Surface that forms the boundary of a Solid object.

Edge = A line segment joining two faces (also a seam).

Vertex = A point in space, by itself or where two or more edges join (also 'Point')

Normal = The direction of a face ('Front' and 'Back').

Isolines = The U/V grid that represents the surface (also 'Isoparms', 'Flow lines', 'Parametrization')

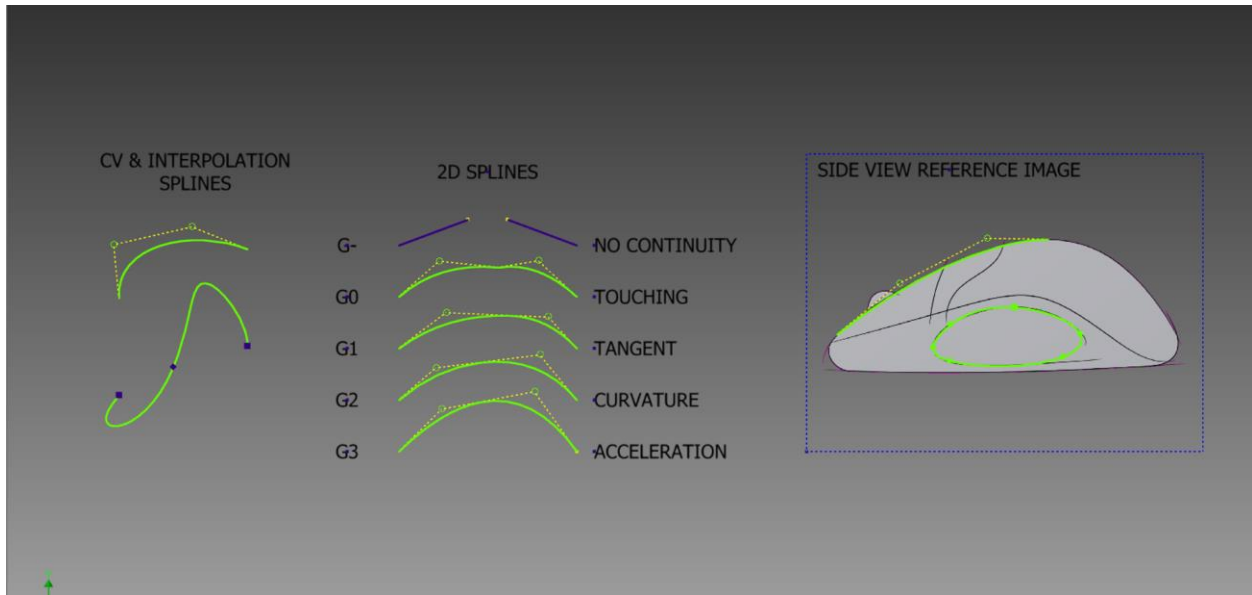**Skin** = An open collection of surfaces (also a 'Quilt')

Volume = A closed collection of surfaces (also a 'Solid')

Manifold = An enclosed volume where the surfaces don't double back and overlap each other.

B-Spline = 'Basis Spline' a mathematical method of fitting a curve through a selection of points.

Acceleration – The rate of change of curvature over the length of the geometry.

Curvature continuity

Curvature continuity is the relationship between two surfaces where they meet at a seam.

Curvature continuity of measured in units of 'G' (Geometry).

Each measure of 'G' represents equal values on each side of the point or seam where curves meet.
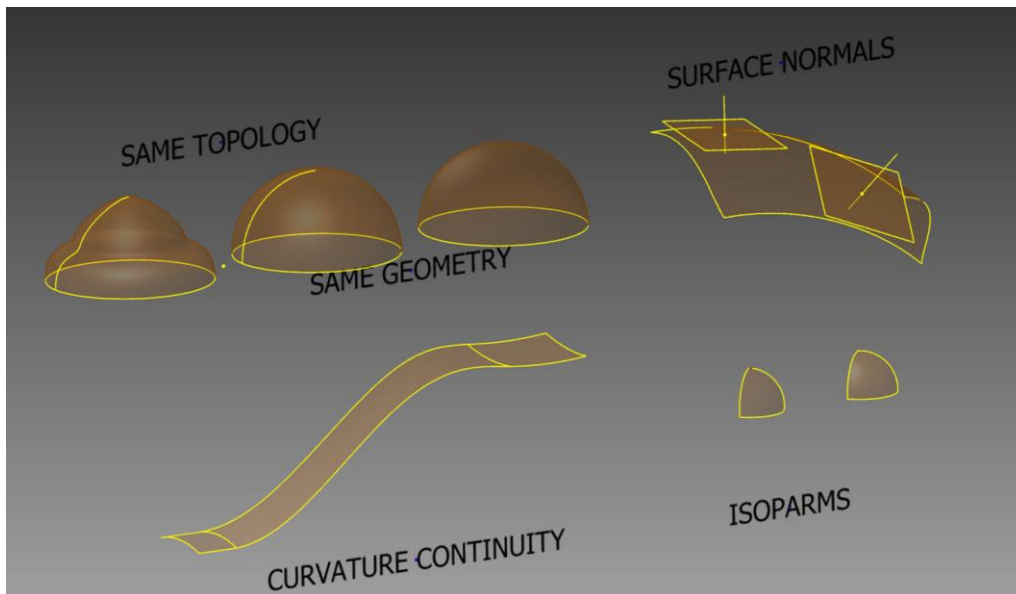
G_ = No continuity, not touching.

G0 = Touching only, a sharp edge.

G1 = Touching and tangency.

G2 = Touching, tangency, and curvature.

G3 = Touching, tangency, curvature and acceleration (rate of curvature change)

Curvature continuity applies to 2D curves as well as 3D seams.

Geometry and Topology
Geometry refers to the shape of the shape of the model. Topology refers to how the model was made. The same shape (Geometry) can be modeled in many different ways (Different Topology).

It's a good idea to build your surface models using the simplest topology that you can.

Surface Normals
All surfaces have a 'Normal'. A surfaces Normal represents its direction. You could think of a Normal direction as being the 'Front' or 'Back' of the surface.

You can represent a Normal by creating a vector that is perpendicular to the face.

Isoparms
Breps are calculated using a four side mesh. This mesh is called 'Isoparms' and is represented by a Grid with a coordinate system represented by the letters U & V.

Be careful of creating surfaces where the Isoparms all collect together into one point. This is called a 'singularity' and no CAD package likes calculating a four side mesh when all the inputs are '0'!

Different surfacing tools will give different results.
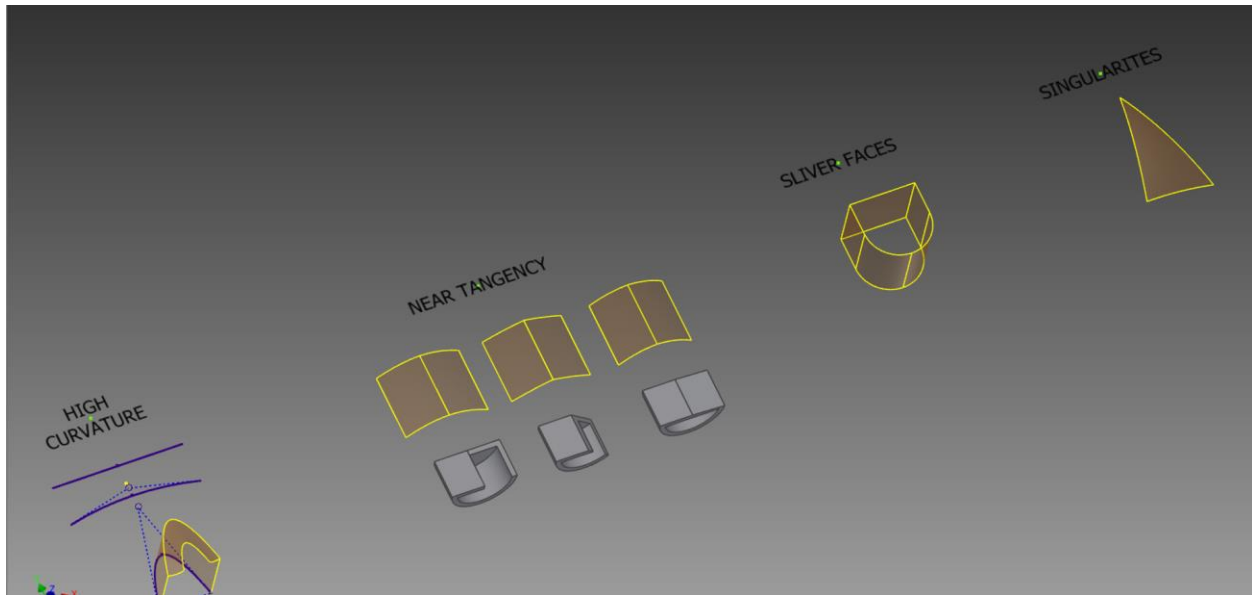
Surfacing Gotchas and trouble shooting

Problems you may encounter include surface degradation (singularities), high curvature and, sliver faces and near tangency.

- High curvature can create self-intersecting geometry. The sweep tool really doesn't like self-intersecting geometry. You may have to use Loft or Patch instead.
- Surface degradation can create surfaces that are difficult to edit. Try 'Overbuilding' surfaces and then trimming them back.
- Near tangency can be hard to spot. Inventor uses a different algorithm for Tangent and non tangent faces. Near tangent faces can give you problems when using Offset, Thicken and Shell commands. Diagnose this with the Fillet or Chamfer tool.
- Sliver faces are tiny faces, usually brought in when importing geometry from another CAD package. Like singularities, Sliver faces also cause Inventor to do a lot of math with very small numbers. A quick tip is to use the Delete face tool with the Heal option to get rid of them.

2D and 3D Sketching

A spline is a curve created between points. Splines are important to surfacing, because they give smooth changes of acceleration. If we want smooth surfaces, we want smooth input geometry.

2D CV & Interpolation Splines

2D Interpolation Splines

Interpolation Splines are created *through* points. You can add or remove points from an interpolation spline at any time. The curvature of the spline can be adjusted at each point (Including the end points).

- Interpolation splines do closed loops very well.
- Interpolation splines, give you lots of control – but take a lot of work to keep under control.
- It's a good idea to create interpolation splines between two points and set the curvature continuity using constraints, before adding in additional points if needed.

2D CV Splines

CV splines a created tangent to a 'Control Frame' made up of CV's (Control Vertices) and 'Hulls' – the lines between CV's. CV splines are much more predictable than Interpolation splines.

CV splines are the work horse of surfacing.

3D Splines

3D splines are used a great deal in surface modeling, mainly as a path for a sweep. Or as a rail for Lofts.

The easiest way to create a 3D spline is to project surface geometry into a 3D sketch.

You can create 3D Interpolation and CV splines directly within a 3D sketch if you need to.

Tip: 3D Sketch geometry can be constrained to surface planes and made parallel to Axis directly, without having to project them into the 3D sketch.

Tip: Use the View cube to align yourself when sketching. This will keep your spline geometry aligned with your view.

Projected curves

3D Curves can be difficult to set up and control. Sometimes, the easiest way to create *predictable* 3D curves is to create 2D curves, and then project them onto 3D geometry.

The project curve tools are found in the 3D sketch environment. You can project curves to a surface, or project two 2D curves to find the 3D equivalent using the Intersection curve tool.

Surfacing tools

Brep surface features
Surface models in Inventor are built using the same tools as solid models, we just use the 'Surface' option.

Algebraic surface features
Algebraic or prismatic shapes are built from 'Regular' geometry, i.e. Lines and arc's. Nurbs surfaces are built from splines. Both types are Brep's, shapes built by trimming surfaces back to boundary geometry.

Algebraic surfaces can be created using

- Extrude
- Revolve
- Loft

Nurbs surface features
Nurbs surfaces built from splines allow us to build complex organic shapes.

Nurbs surfaces can be built using

- Loft
- Sweep
- Patch

Editing Surface Features
Surfaces can be trimmed, split copied and moved using Inventor's surface tools.

Trim = *Trim surface*

Split = *Split face tool*

Copy = *Thicken/Offset tool*

Move = *Move body (Remember to select the Surface Body, not the surface itself)*

You can add to a surface feature using

Extend = *Make the surface bigger*

Rule surface = *Create a perpendicular or tangent surface from and edge.*

Filleting surfaces
You cannot fillet two surfaces that are not joined together. To joint two surfaces together, use the 'Stitch' command, then apply the fillet.

Converting from Surfaces to solids
Surfaces can be converted to solids using the Stitch command or the Sculpt command. Both commands will create a solid, as long as the surfaces you select define an enclosed, water tight, manifold volume.

You can turn an open surface into a solid using the Thicken/Offset command.

Tip: Thicken/Offset gives a different result to shell – check it out and see.
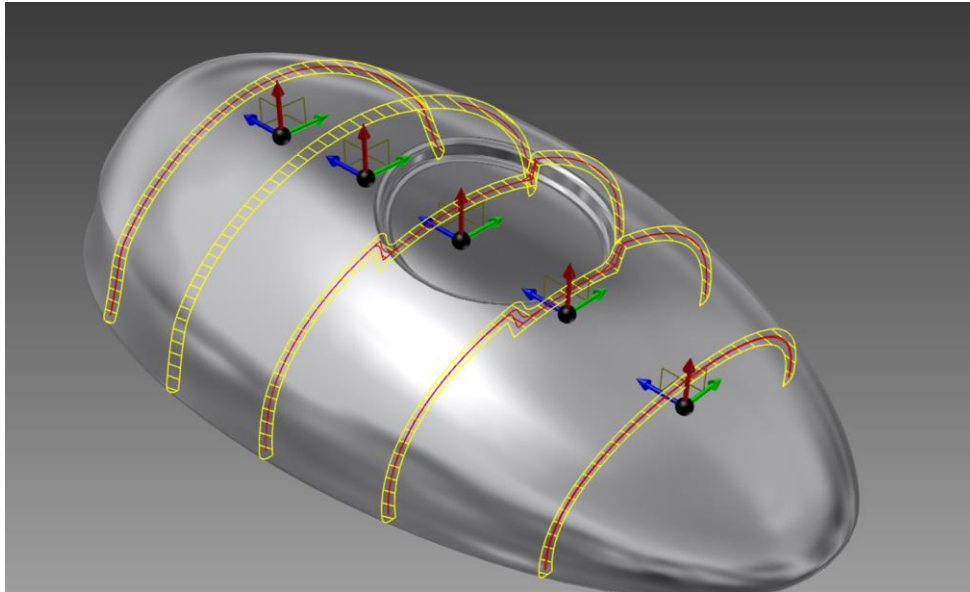
Surface analysis

Surfacing analysis tools can be found in the 'Inspect' tab.

Tip: I Like to use 'Chrome' appearance as my default appearance when surface modeling, because it makes discrepancies in surface continuity easier to spot without having to use the analysis tools.

- Zebra stripes project black and white stripes onto your surface to help you see the continuity between surfaces.
  Tip: works best in 'Shaded mode'.
- Curvature can be used to analysis the curvature and acceleration across surface seams and quilts.
  Tip: Set all curvature to Zero to get a representation of the surface Isoparms.
- *Section analysis can be used to look for thin walls.*

Conclusion

Building complex geometry in Inventor can be complicated if you don't know how. In this class I hope to have given you a great deal of theory that you can use to create 'smooth' organic models inside any CAD package.

We also looked at the surface modelling tools inside Inventor and talked about how we can apply the theories we have learned.

I hope that you are now confident enough to tackle this knowledge and go try it on your projects.

Let me know how you get on:

Paul@Cadsetterout.com

http://cadsetterout.com/autodesk-inventor-surface-modeling/